Geophysical Research Abstracts
Vol. 21, EGU2019-1851, 2019
EGU General Assembly 2019

Forest density influences on surface energy and soil thermal dynamics in Siberian larch forests underlain by permafrost

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Boreal ecosystems are undergoing rapid changes in direct response to climate warming and through secondary effects of climate on key ecosystem processes such as altered disturbance regimes. In many cases these altered ecological processes foster changes in the dominant vegetation type that range from subtle increases in forest canopy cover, to changes in forest type, or even transitions between forested and non-forested ecosystems. Such changes are climatically important, but altered carbon, water, and energy dynamics can have opposing impacts on climate, so their sign and magnitude remain difficult to discern. In boreal North America, altered fire regimes are leading to rapid and persistent changes in vegetation that fundamentally alter biogeophysical interactions between ecosystems and climate. However in boreal Siberia, interactions between fire, biogeophysical processes, and climate are less well understood.

This study examines differences in surface energy exchange and evapotranspiration between high- and low-density larch forests (71% and 13% canopy cover, respectively) that are underlain by permafrost in northeastern Siberia. The two forest stands are located within a single burn perimeter, where variability in burn severity resulted in heterogeneous forest cover. Using observations of net radiation above and below the forest canopy, soil temperatures and heat flux, canopy dynamics, and transpiration, we examined how fire induced changes in forest density alter land surface energy dynamics. We observed the expected reductions in albedo in denser forests, particularly during periods of snow cover. However, we also found that differences in canopy cover had important effects on soil temperatures and permafrost thaw depths at scales ranging from diurnal to seasonal. In addition we found that differences in transpiration between the two stands varied widely with key environmental drivers and were small when water was limiting. Our results show that the effects of fire on forest density in boreal Siberia have important implications for ecosystem biogeophysical processes.